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WESTERN SPRUCE BUDWORM DAMAGE ASSESSMENT PROJECT

1979

Progress Report No. 2

by

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I. INTRODUCTION

The western spruce budworm, Choristoneura occidentalis Freeman, is a major defoliator of Douglas-fir (Pseudotsuga menziesii) and true fir (Abies spp.) in the western United States. During outbreaks of this insect, repeated defoliation of host trees causes growth loss, top-kill, and tree mortality. Faced with these serious tree damages, a forest manager must decide if control is warranted, and if it is, determine what control method is preferred. The manager must select a method that will be effective, economical, and environmentally acceptable, as well as compatible with management objectives. In order to make these decisions, the manager must have reliable damage information.

In the Southwest, little information has been collected on tree losses caused by the budworm; thus, a long-term damage assessment project was initiated in 1978. This report summarizes the methods used to assess tree damages and the results of sampling for 1978 and 1979.

II. OBJECTIVES

The purpose of this evalution is to assess damages to Douglas-fir, true fir, and spruce caused by the western spruce budworm on the Carson National Forest, New Mexico. Specific objectives of the evaluation follow:

A. Growth Loss

1. Determine the amount of growth loss and recovery for past infestations that occurred from 1922-1966, and the current infestation which began in 1975.

2. Estimate densities of larvae and egg masses and relate these population indexes to tree defoliation and subsequent growth loss.

3. Determine if differences in growth loss and recovery occur between site classes and timber size classes.

4. Determine if a relationship of defoliation to growth loss can be established for site and size classes.

B. Top-kill and Tree Mortality

1. Determine the annual amount of top-kill and tree mortality caused by the current budworm infestation.

2. Estimate densities of larvae and egg masses and relate these population indexes to tree defoliation and subsequent top-kill and mortality.

3. Determine if a relationship of defoliation to top-kill and mortality can be established for site classes and timber size classes.

III. OUTBREAK HISTORY

The evaluation areas are located on the Taos, Questa, and Tres Piedras Ranger Districts of the Carson National Forest (Fig. 1, Appendix).

Several infestation cycles of budworm have occurred on this Forest since 1922. On the western part of the Carson, including the Tres Piedras District, an outbreak occurred from approximately 1922 to 1935. Then in the early 1940's, and again during the 1950's, widespread infestations occurred on the Tres Piedras, Taos, and Questa Ranger Districts. Infested areas on the Tres Piedras were sprayed with DDT in 1955. Another budworm outbreak occurred in the 1960's and portions of the following units were treated with DDT: Taos Ranger District, 1962; Tres Piedras, 1963; and Taos and Questa Ranger Districts, 1966. The infestation remained in untreated portions of the Taos and Questa Ranger Districts until 1968, and then collapsed. No visible defoliation has been documented on the Tres Piedras Ranger District since 1963.

The current infestation was detected in 1975 when 520 acres of defoliation were observed in the Rio Pueblo de Taos watershed, Taos Pueblo Indian Reservation. The infestation increased manyfold in 1976 on the Reservation and the adjoining Carson National Forest. An aerial survey of the Taos and Questa Districts in 1978 revealed over 15,000 acres of defoliation (classified as light to heavy); and in 1979, over 30,500 acres. Egg mass data indicate the outbreak will continue to increase in size and intensity in 1980.

IV. METHODS

A. Block Establishment

Twelve, 1-acre blocks were permanently established in June 1978: three blocks in the Cabresto Creek drainage on the Questa Ranger District and nine blocks in drainages of the Rio Fernando de Taos on the Taos Ranger District (Figs. 2-6, Appendix). None of the blocks were located in the initial outbreak area where defoliation was detected in 1975. Little or no defoliation occurred on these blocks prior to their establishment.

In 1979, five additional blocks were established: one block near Burned Mountain on the Tres Piedras Ranger District and four blocks near Osha Mountain on the Taos Ranger District (Figures 7 and 8, Appendix). The Burned Mountain block (Number 17) is located outside the current infestation area and will serve as a check block. Blocks 13 through 16 were originally intended as check blocks, but became infested with budworm. Except for block 14, they may not be sampled again until the final year of the project.

Block 14 is infected with dwarf mistletoe and will be sampled yearly for tree damages. Dwarf mistletoe is widespread in Douglas-fir stands on the Carson National Forest and causes tree damages similar to those done by budworm. For this reason, blocks 1 through 12 were located deliberately in stands with little or no mistletoe; otherwise, it would have been difficult to analyze damages due to budworm. Block 14 will be monitored in order to obtain data on damages which result when budworm infests a stand infected with mistletoe. Heavier tree damages may occur when both of these agents are present.

All blocks were permanently marked using paint and flagging, witness trees, and corner stakes. Blocks were located to provide a repre-

sentative sample of three site classes and the past infestations. Three Douglas-fir site trees were measured on each block to determine site index. Site class codes were determined from site index values as follows:

Site Class Code

I	site index 75 or above
II	site index 55-74
III	site index 54 or below

On each block (the year it was established), all trees (including nonhost species) with a d.b.h. of 5 inches or greater were recorded. All sample trees were permanently tagged with block and tree numbers. The following information was obtained from each tree:

1. Species
2. Height (to nearest foot)
3. D.b.h. (to nearest 0.1 inch)
4. Amount of top-kill (length to nearest foot)
5. Condition (live or dead)
6. Crown ratio

On each block, a subsample of nine, 1/100-acre circular fixed plots were established to assess budworm damage to regeneration-size trees. Plot centers were located on a 90-foot grid in each block (Fig. 9, Appendix). All trees less than 5 inches in d.b.h. were examined and the following information recorded:

1. Species
2. D.b.h. (to nearest 0.1 inch)
3. Height (to nearest inch)
4. Visual estimate of defoliation (light, medium, or heavy)
5. Condition (live or dead)

B. Damage Assessment

1. Defoliation

On each block, 25 Douglas-fir trees, 20-40 feet in height, were selected for sampling defoliation in 1978 through 1983. To reduce the effect of sampling on individual trees, only 10 of the 25 were to be sampled each year (i.e., 1978, trees 1-10; 1979, trees 11-20; 1980, trees 21-25 and 1-5; etc.). Two methods were used to estimate defoliation:

a. Visual method [1/]. Each sample tree was divided into three crown levels: upper, middle, and lower. Using binoculars, two observers made independent visual estimates of the percent defoliation of each crown level. These estimates were tallied by recording the midpoint value of the defoliation class in which each estimate belonged. The defoliation classes and midpoint values were as follows:

1/ Carolin, V. M., and W. K. Coulter. 1972. Sampling populations of western spruce budworm and predicting defoliation on Douglas-fir in eastern Oregon. USDA Forest Serv. Res. Pap. PNW-149. 39 pp.

Defoliation class %	Midpoint value %
0-10	5
11-25	18
26-50	38
51-75	63
76-90	83
91-100	95

The two midpoint values for a crown level were averaged and the resultant figure weighted using the following values: lower crown - 5, middle crown - 3, and upper crown - 1. The average midpoint value multiplied by the assigned weight gave the average defoliation of the crown level.

The sum of the three weighed averages was then divided by nine to give percent defoliation for the entire tree.

b. 6-class system.[2/] This method involved sampling four apical branches: a branch (70 cm in length) from each quadrant at midcrown of each sample tree. On each branch sample, 25 new shoots were examined for current defoliation using the left side of one branch and the right side of another, and so on. Each new shoot was individually examined for defoliation and assigned an index and midpoint value as follows:

Defoliation class %	Index value	Midpoint value
0	0	0
1-25	1	12.5
26-50	2	37.5
51-75	3	62.5
76-99	4	87.5
100	5	100

After index values were determined for the branch samples, individual tree defoliation was calculated using the following formula:

$$\% \text{ defoliation} = \frac{(n_1)\ (12.5) + (n_2)\ (37.5) + (n_3)\ (62.5) + (n_4)\ (87.5) + (n_5)\ (100)}{100}$$

Where n_1 = number of twiglets with index value 1
n_2 = number of twiglets with index value 2
n_3 = number of twiglets with index value 3
n_4 = number of twiglets with index value 4
n_5 = number of twiglets with index value 5

2/ Parker, D. L., R. E. Acciavatti, and E. D. Lessard. 1978. Western spruce budworm suppression and evaluation project using carbaryl, 1977. Progress Rep. No. 1, USDA Forest Serv., Southwestern Reg. 136 pp.

In both the visual method and the 6-class system, block defoliation was simply the average of the individual tree values.

2. Growth Loss

Core samples were taken from host trees in an attempt to measure radial growth loss and recovery for past infestations which occurred on the Carson National Forest from 1922 to 1966. Nonhost trees were sampled to determine expected growth of host trees and to help identify periods of growth loss due to other factors, such as drought.

On each block, two core samples per tree were taken from 30 sample trees: 10 Douglas-fir, 10 true fir, and 10 ponderosa pine. The core samples were placed in plastic straws for storage and labeled with plot number, tree number, and species. Radial growth measurements were done on an Addo System by the Intermountain Forest and Range Experiment Station, Moscow, Idaho.

Core samples will be taken during the final year of the project to determine when the current infestation began to affect radial growth and by what amount. The samples will also be analyzed to see if differences in growth reduction occurred between stands with different site classes and timber size classes.

3. Top-kill and Tree Mortality

Top-kill and tree mortality were recorded on all blocks. Both the incidence and amount of top-kill were measured. The length of the dead top, to the nearest foot, was estimated. All top-kill and tree mortality not attributed to the present infestation were recorded as old, and will be used as a base line for future damage assessment. All top-kill and tree mortality due to the present infestation were recorded each year.

Trees have the ability to establish adventitious buds after intense defoliation, thereby providing tree recovery. For this reason, top-kill and tree mortality are difficult to identify. Therefore, all top-kill and tree mortality will be verified for at least 2 years following the initial determination.

4. Seedling and Sapling Top-kill and Mortality

The condition of seedlings and saplings was checked annually. Trees less than 0.5 inches in d.b.h. were classed as seedlings. Trees with a d.b.h. of 0.5 to 4.9 inches were classed as saplings. The plots established in 1978 were reexamined in 1979. Data were recorded on tree mortality, top-kill, and defoliation.

C. Insect Densities

On each block, 25 Douglas-fir trees, 20-40 feet in height, were selected for sampling insect densities. To reduce the effect of sampling on individual trees, only 10 of the 25 were to be sampled each year (i.e., 1978, trees 1-10; 1979, 11-20; 1980, 21-25 and 1-5; etc.). These sample trees were the same as those selected for defoliation sampling.

1. Larvae

Sampling was begun when 20 percent of the larvae were in the fifth instar or larger. On each tree, two 15-inch branches were cut from opposite sides of the midcrown using a pole pruner with attached collecting bag. If a sample branch did not have at least 15 live buds, another branch was cut. The length and width of branches were recorded to determine the foliated branch surface area.

Larvae were removed from sample branches, counted, and preserved in ethyl alcohol. Vials containing the larvae were labeled with block and tree numbers and the collection date. Total numbers of larvae and live buds per branch were recorded.

2. Egg Masses

Egg masses were sampled by cutting two 70 cm midcrown branches from opposite sides of each sample tree. Branches were obtained by using a pole pruner equipped with a collecting bag. The length and width of branches were measured to calculate foliated branch surface area. Each branch was then individually bagged in a 1/4-bushel paper sack, transported to the laboratory, and stored at about 40° F prior to examination.

Foliage was examined under ultraviolet light for egg masses. Needles bearing egg masses were classed as from current year's foliage or a previous year's and kept separate in labeled pill boxes. New egg masses (deposited in the year of sampling) were separated from old egg masses (deposited in the year(s) before sampling) under a stereomicroscope. All egg masses on current year's foliage were classed as new and their characteristics formed the basis for aging those egg masses found on a previous year's foliage.

V. RESULTS

A. Block Establishment

Seventeen blocks were established: blocks 1 through 12, 1978; and blocks 13 through 17 in 1979. The productivity of a site to grow Douglas-fir (site index) was used as the primary criterion for block selection. On some blocks it was difficult to find satisfactory sample trees to determine the site index. Nevertheless, there should be sufficient replication to determine if insect densities and resulting tree damages and losses vary among low, moderate, and high productivity sites.

When each block was established, all trees 5 inches in diameter and larger were recorded to form a basis to determine future effects resulting from the current outbreak. With the exception of block 4, which had about 60 percent ponderosa pine, species attacked by the budworm (host tree) were most abundant. Densities of trees ranged from 66 to 320 trees per acre. Refer to Table 2, Appendix, for species diversity and stocking density data.

For trees less than 5 inches in diameter, the total number of trees on nine, 1/100-acre plots ranged from 63 to 330 trees (Table 3,

Appendix). Host trees comprised about 42 to 100 percent of all trees, and white fir generally was the predominant species.

B. Damage Assessment

1. Defoliation

Defoliation estimates for pole- and sawtimber-sized Douglas-fir in 1978 and 1979, are shown in Table 4, Appendix. On plots 1 through 12, where 2 years of data have been collected, the overall average defoliation increased from 1978 to 1979: visual method, 41 to 80 percent; 6-class system, 53 to 82 percent. The highest block defoliation found by either method was 70.2 percent in 1978, and 95.2 percent in 1979. Blocks 13 through 16, which became infested with budworm in 1979 had low defoliation estimates which averaged 5 percent for the visual method and 8 percent for the 6-class system.

After several years, an analysis will be made to determine the intensity of defoliation required to cause top-kill and tree mortality. The total defoliation over time will be used as the measure of defoliation intensity. That is, if a particular tree has been top-killed by budworm after 3 years of continuous defoliation--30 percent in year 1, 50 percent in year 2, and 90 percent in year 3--the defoliation intensity will be recorded as 170 percent. It may be that a particular sequence of yearly defoliation will cause top-kill. As an example, 30, 50, and 90 percent annual defoliation may cause top-kill, but 90, 50, and 30 percent may not cause top-kill. Both would have the same defoliation intensity--170 percent. Therefore, both defoliation intensity and sequence of defoliation will be examined.

2. Growth Loss

Increment cores were measured to determine the effect of budworm defoliation on radial growth. Measurements of the cores taken in 1978 (blocks 1-12) and 1979 (blocks 13-17) are being analyzed. An attempt will be made to analyze the effects of past infestations on the different site classes and timber size classes, and present these data in the 1980 progress report.

3. Top-kill and Tree Mortality

Permanent tree damages began to appear in 1978--3 years after visible defoliation occurred on the Forest--and increased in 1979. Loss assessment data for budworm have never been collected in the Southwest, especially on a yearly basis, and the current data indicate that tree damages and losses may be heavier than anticipated. For host trees 5 inches in diameter and greater, an average of 2 percent of the trees on blocks 1 through 12 were top-killed in 1978 (Table 5, Appendix). However, about a quarter of the trees on blocks 5 and 6 were top-killed. This level of damage is much heavier than would be expected, especially since these stands had the lowest density of host trees and a high percentage of pine. In 1979, an average of about 21 percent of the host trees on blocks 1 through 12 were top-killed. However, no top-kill occurred on blocks 13 through 17--blocks 13 through 16 first became infested in 1979, and block 17 was uninfested with budworm.

Mortality of trees 5 inches in diameter and larger began in 1979. One tree each on blocks 1, 5, and 7 died as a result of the repeated defoliation.

Top-kill and mortality of trees less than 5 inches in diameter were at very low levels in 1978 and increased in 1979 (Table 6, Appendix). On blocks 1 through 12 in 1979, the average percent of top-killed trees (1.2 percent) is less than that recorded for larger trees (21.3 percent); however, a higher percentage of seedlings and saplings were killed (1.2 percent versus 0.2 percent). The reason why these seedlings and saplings were not affected to the same degree as the larger trees is unknown.

Little or no defoliation had occurred on blocks 1 through 12 prior to 1978 and on blocks 13 through 17 prior to 1979. Much of the damage to seedlings and saplings found at the time of plot establishment was probably due to factors other than the budworm. For example, one of the highest levels of seedling and sapling top-kill was found on the uninfested check block (8.8 percent in 1979). Therefore, seedling and sapling damage found the year of plot establishment will be used as baseline data and will not be attributed to budworm.

C. Insect Densities

Larval and egg mass density data show that the infestation has been at a relatively high level in some blocks for 2 years, and the infestation is generally increasing in most blocks (Table 7, Appendix). The heaviest densities were on blocks 1 through 8 and 10 through 12. The densities of larvae were low in blocks 13 through 16, but densities of eggs indicate that larval densities will be much higher in 1980. No attempt was made to relate densities of insects to defoliation.

VI. PLANS FOR F.Y. 1980

Data will continue to be collected on defoliation, tree damages and losses, and insect densities.

Also, an attempt will be made to analyze core data to determine the effects of past infestations on radial growth.

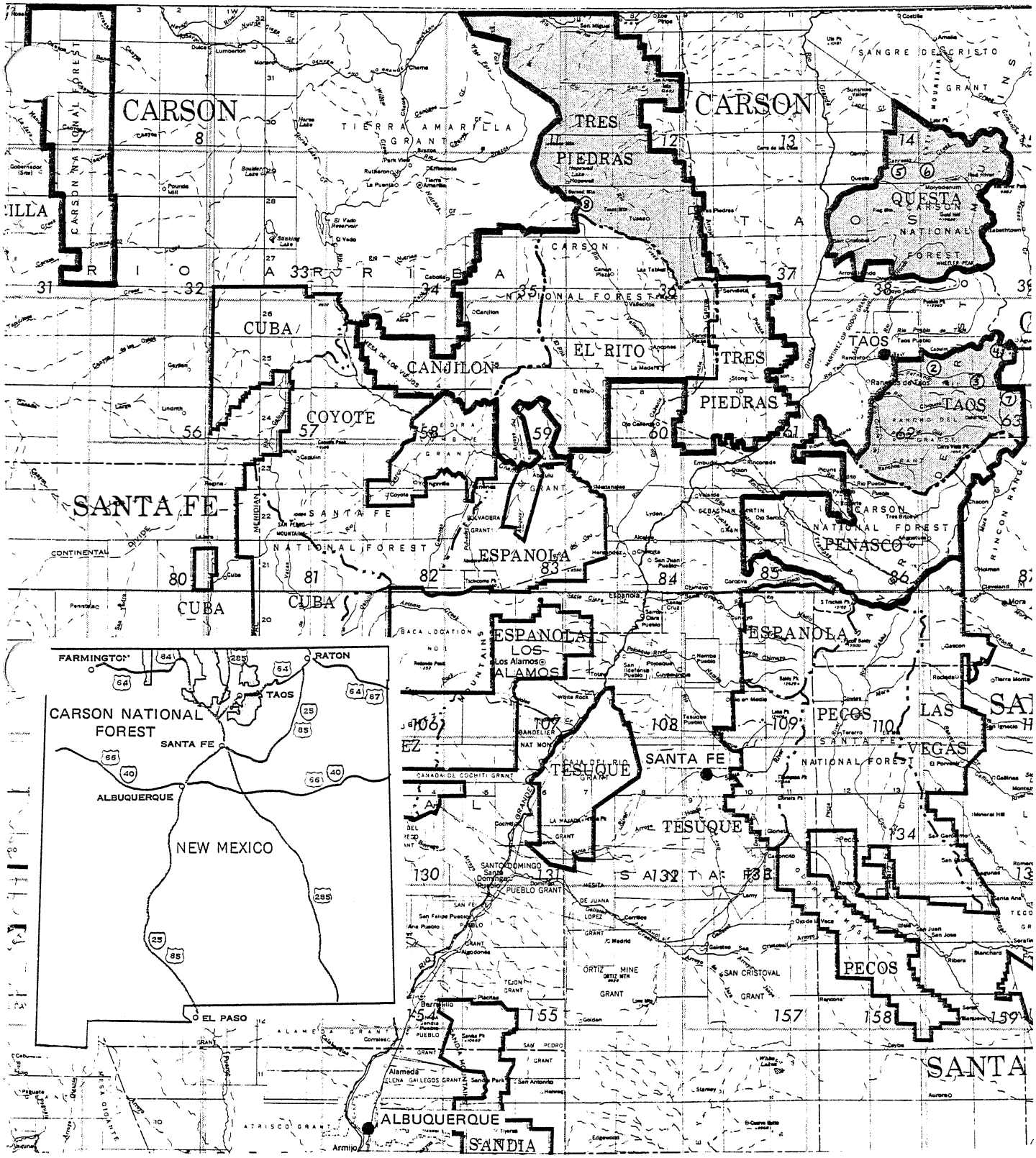

Figure 1. General location of evaluation blocks for the Spruce Budworm Damage Assessment Project on the Tres Piedras, Questa, and Taos Ranger Districts, Carson National Forest, 1978-79. Numbers (②-⑧) indicate subsequent maps (Figures 2-8) which show specific locations of 17 evaluation blocks.

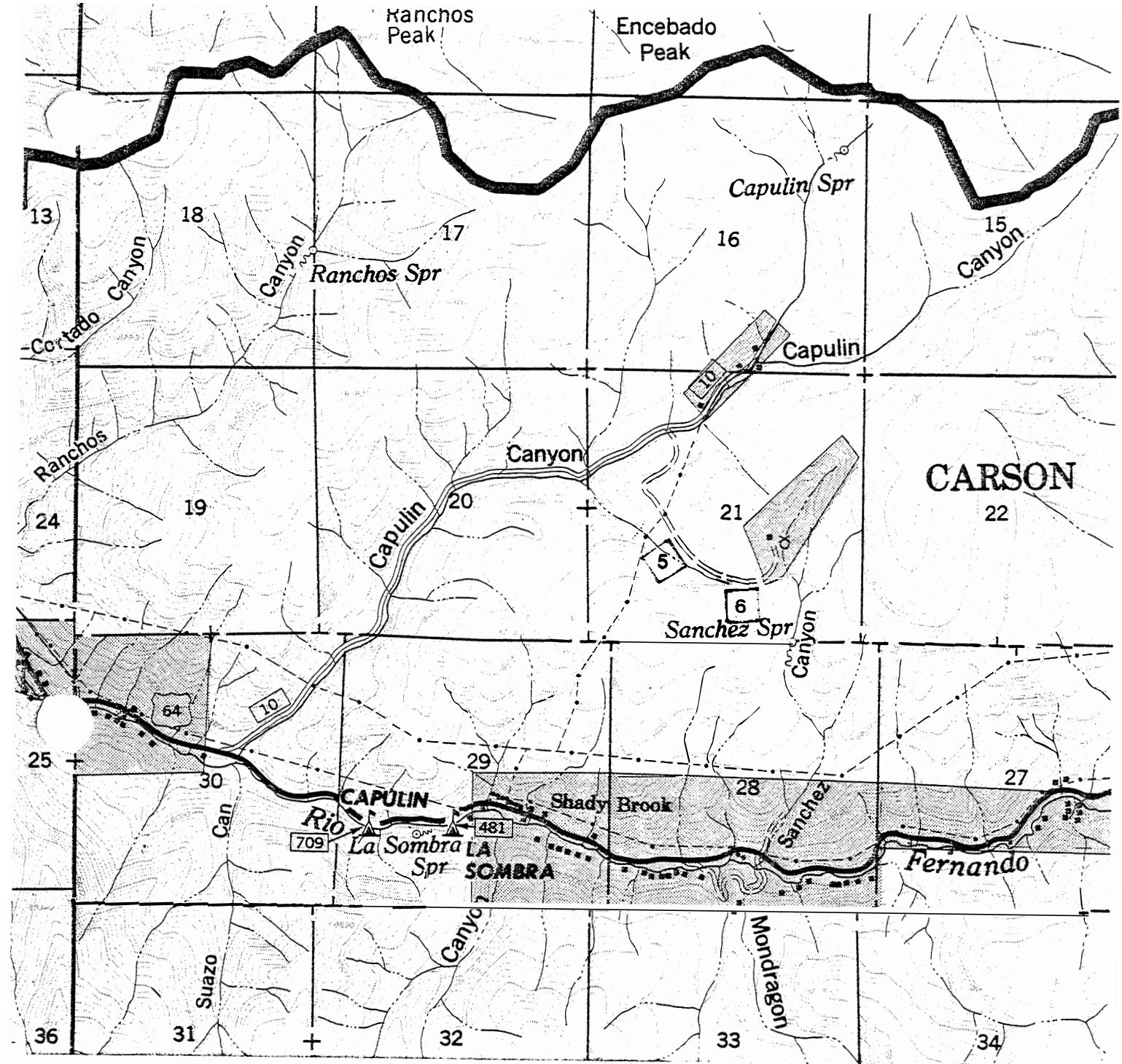

Figure 2.--Location of blocks 5 and 6, Western Spruce Budworm Damage Assessment Project, Taos Ranger District, Carson National Forest, 1978-79

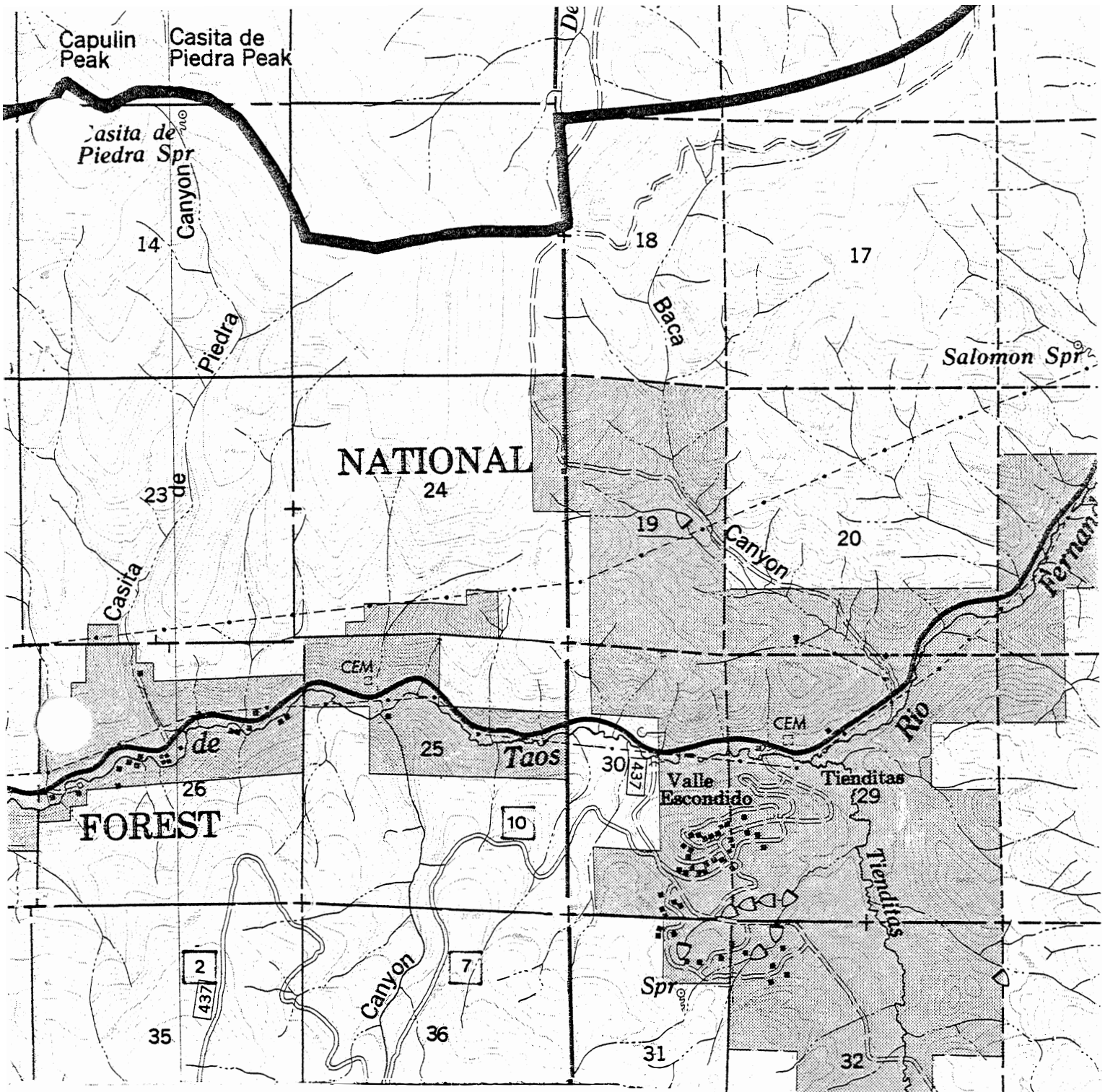

Figure 3.--Location of blocks 2, 7, and 10, Western Spruce Budworm Damage Assessment Project, Taos, Ranger District, Carson National Forest, 1978-79.

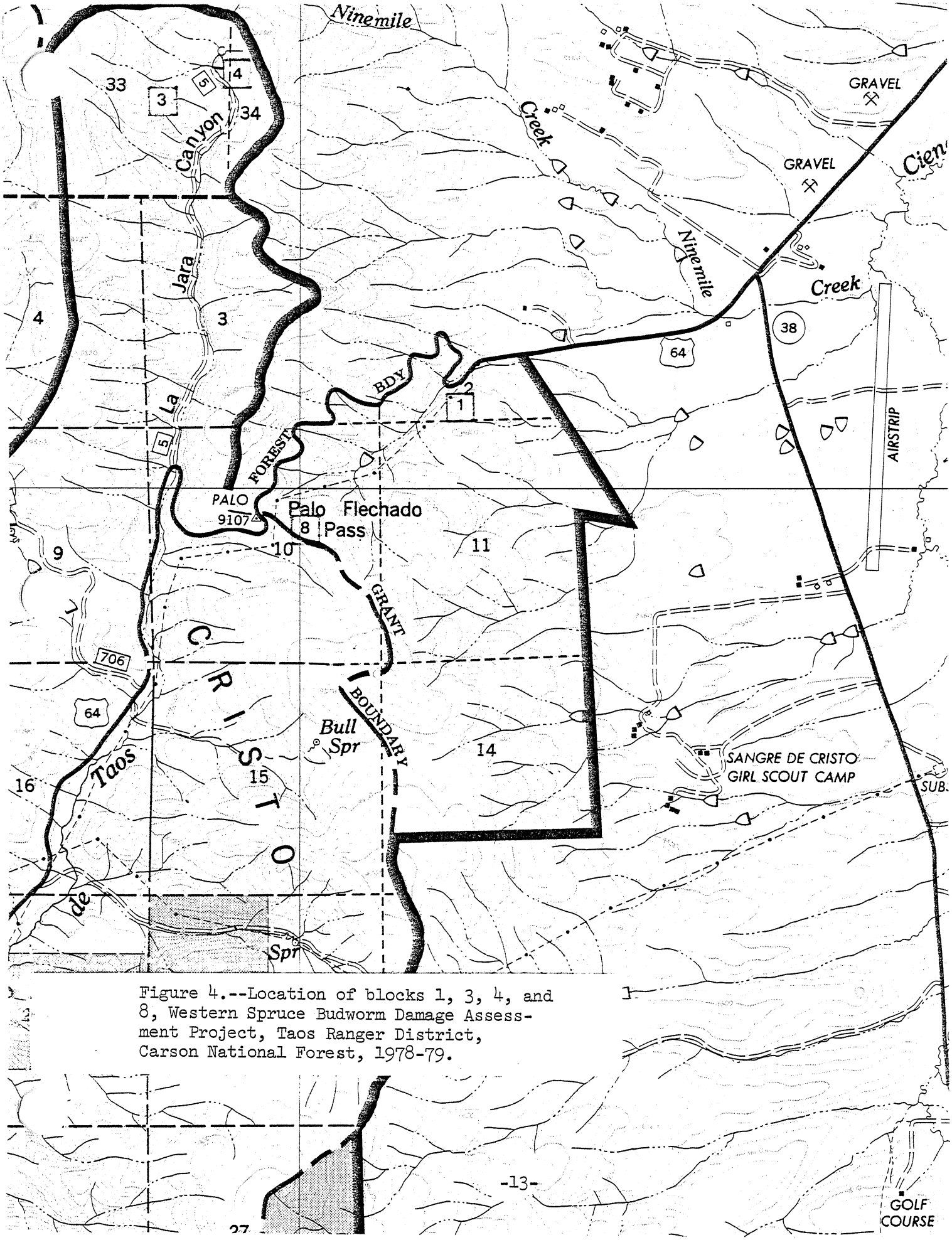

Figure 4.--Location of blocks 1, 3, 4, and 8, Western Spruce Budworm Damage Assessment Project, Taos Ranger District, Carson National Forest, 1978-79.

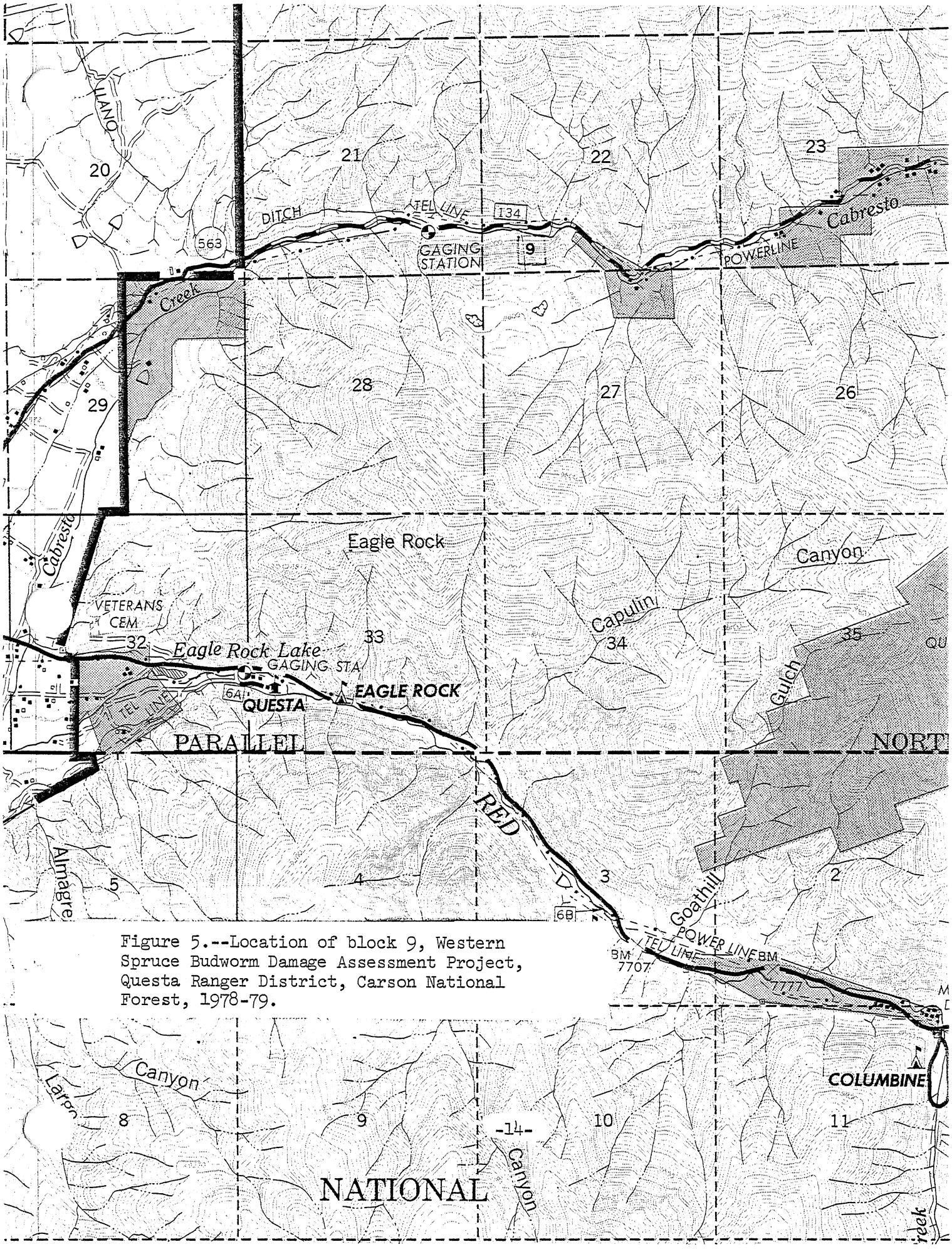

Figure 5.--Location of block 9, Western Spruce Budworm Damage Assessment Project, Questa Ranger District, Carson National Forest, 1978-79.

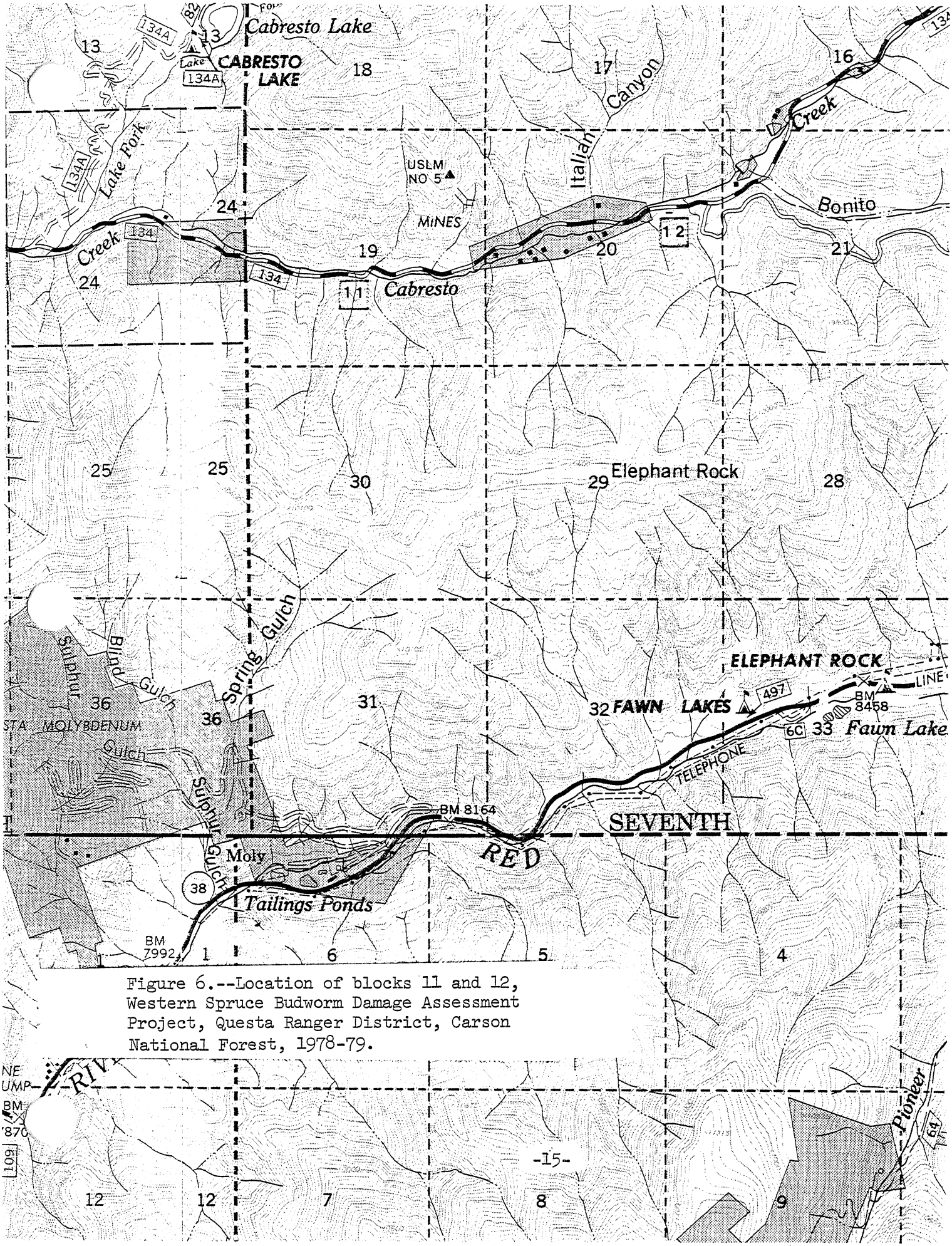

Figure 6.--Location of blocks 11 and 12, Western Spruce Budworm Damage Assessment Project, Questa Ranger District, Carson National Forest, 1978-79.

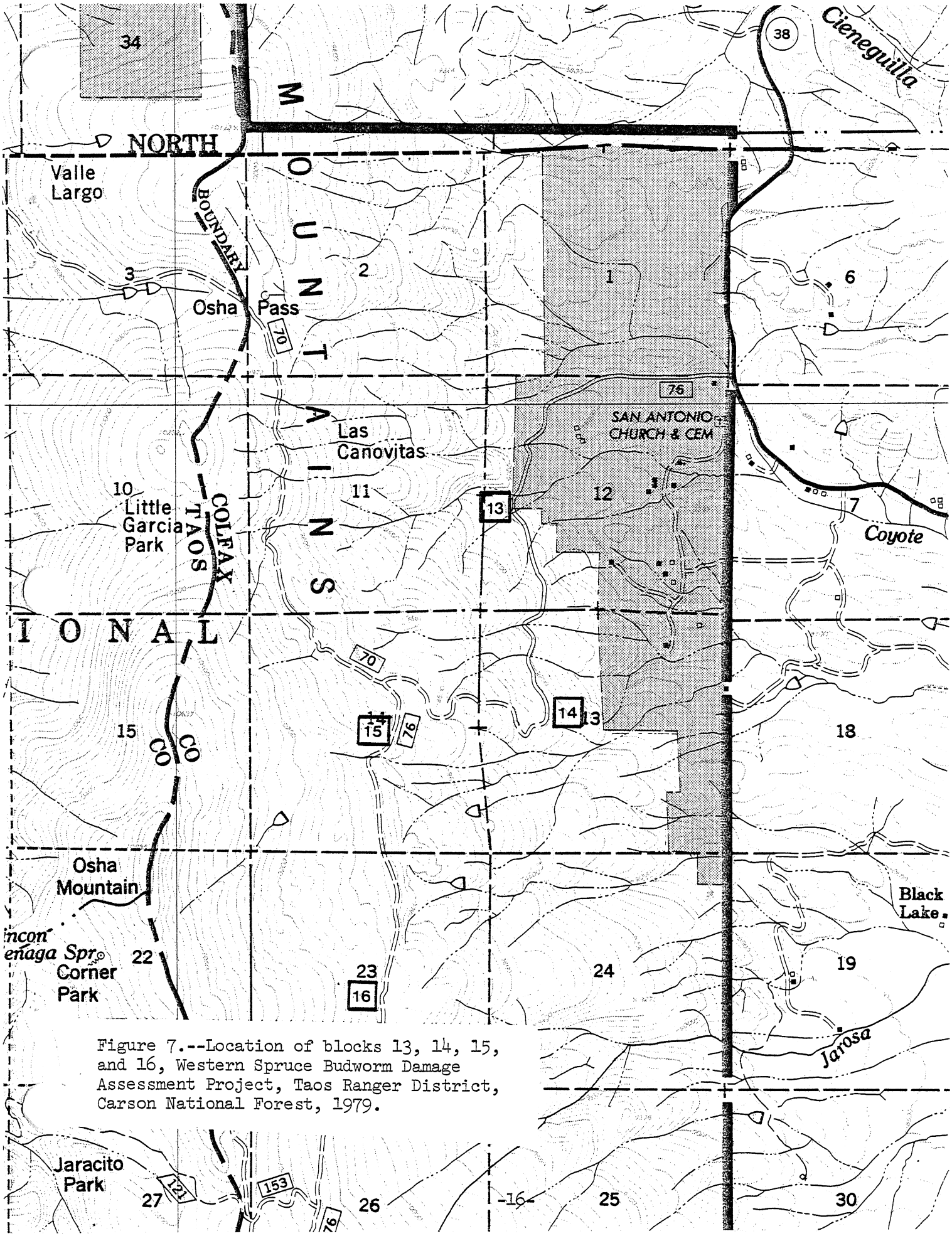

Figure 7.--Location of blocks 13, 14, 15, and 16, Western Spruce Budworm Damage Assessment Project, Taos Ranger District, Carson National Forest, 1979.

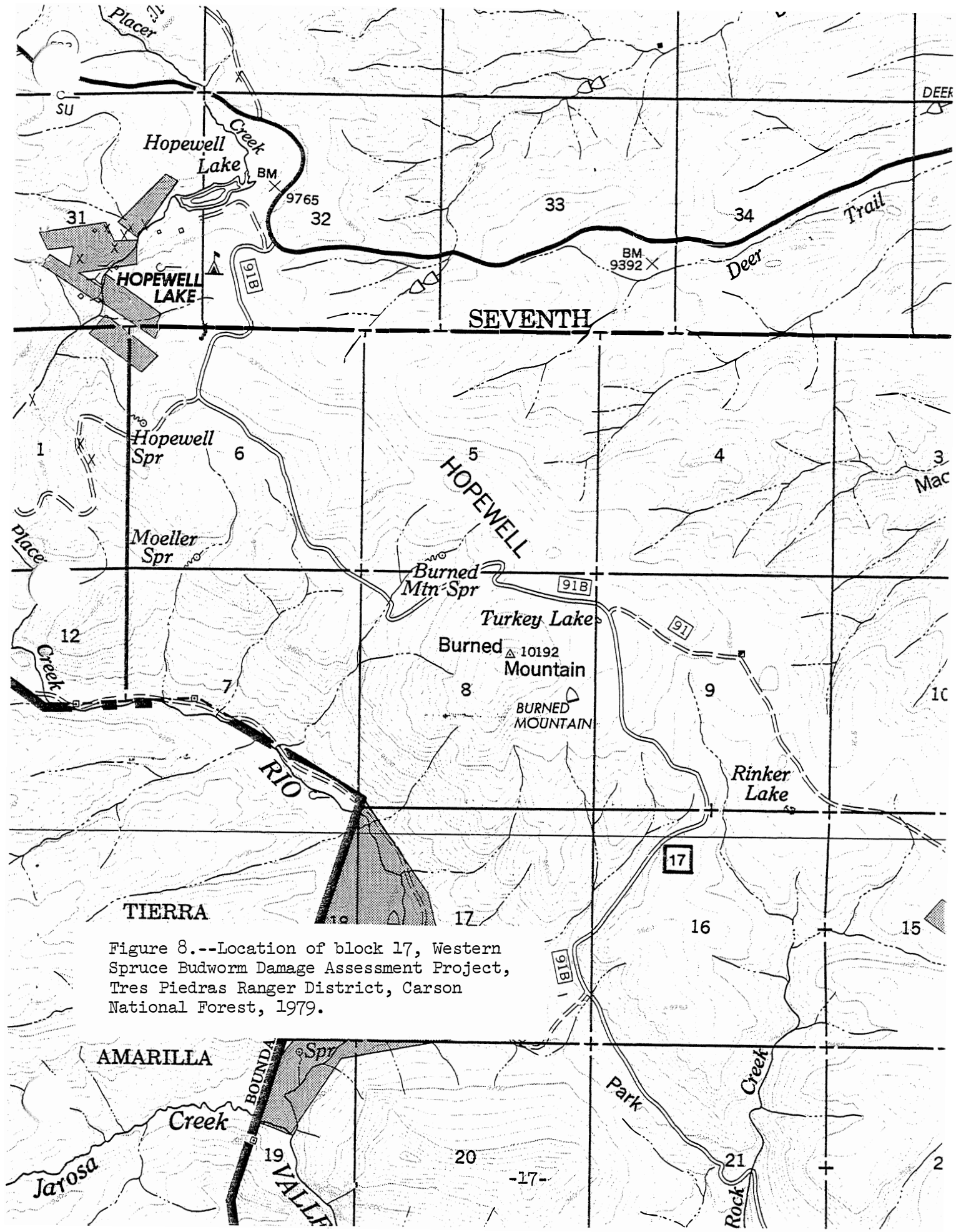

Figure 8.--Location of block 17, Western Spruce Budworm Damage Assessment Project, Tres Piedras Ranger District, Carson National Forest, 1979.

Figure 9.--Layout of 1/100-acre circular plots on 1-acre blocks, Western Spruce Budworm Damage Assessment Project, Carson National Forest, New Mexico, 1978-79.

Scale is 2" = 100'

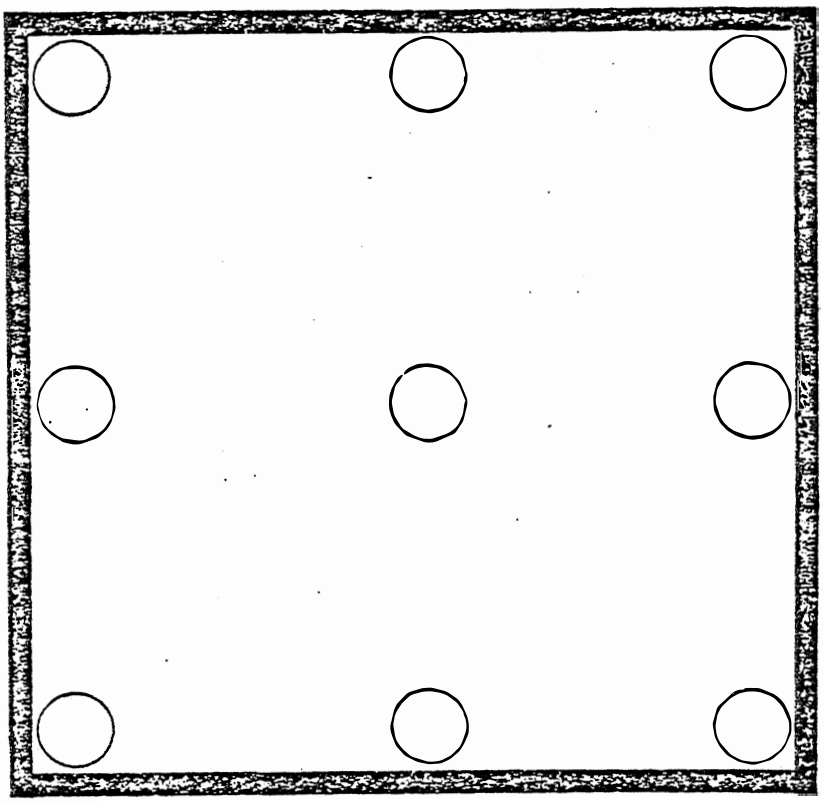

Table 1.--Douglas-fir site index and class for 1-acre blocks, Western Spruce Budworm Damage Assessment Project, Carson National Forest, New Mexico, 1978-1979.

Location	Block	Site index	Site class
Rio Fernando de Taos	1	50	III
Rio Fernando de Taos	2	50	III
Rio Fernando de Taos	3	70	II
Rio Fernando de Taos	4	80	I
Rio Fernando de Taos	5	80	I
Rio Fernando de Taos	6	50	III
Rio Fernando de Taos	7	60	II
Rio Fernando de Taos	8	70	II
Cabresto Creek	9	80	I
Rio Fernando de Taos	10	60	II
Cabresto Creek	11	90	I
Cabresto Creek	12	80	I
Osha Mountain	13	70	II
Osha Mountain	14	60	II
Osha Mountain	15	60	II
Osha Mountain	16	80	I
Burned Mountain	17	60	II

Table 2.--Species composition for trees 5 inches in d.b.h. or greater, Western Spruce Budworm Damage Assessment Project, Carson National Forest, New Mexico, 1978-79.

Block	Stocking density								Total no. trees/acre
	Douglas-fir		True fir		Spruce		Pine		
	No.	%	No.	%	No.	%	No.	%	
1	120	62.5	62	32.3	8	4.2	2	1.0	192
2	202	87.8	15	6.5	1	0.5	12	5.2	230
3	46	44.2	13	12.5	44	42.3	1	1.0	104
4	76	63.9	5	4.2	37	31.1	1	0.8	119
5	21	29.2	8	11.1	0	.0	43	59.7	72
6	29	43.9	20	30.3	0	.0	17	25.8	66
7	210	83.0	6	2.4	0	.0	37	14.6	253
8	119	71.7	18	10.8	1	0.6	28	16.9	166
9	94	70.1	4	3.0	0	.0	36	26.9	134
10	83	50.0	20	12.1	2	1.2	61	36.7	166
11	85	66.4	20	15.6	22	17.2	1	0.8	128
12	112	65.1	10	5.8	49	28.5	1	0.6	172
13	153	93.9	7	4.3	3	1.8	0	.0	163
14	85	45.2	51	27.1	5	2.7	47	25.0	188
15	111	62.7	14	7.9	52	29.4	0	.0	177
16	40	12.5	54	16.9	226	70.6	0	.0	320
17	167	81.9	15	7.3	22	10.8	0	.0	204

Table 3.--Species composition for trees less than 5 inches d.b.h., Western Spruce Budworm Damage Assessment Project, Carson National Forest, New Mexico, 1978-79.

Block	Stocking Density										Total trees on 9, 1/100-acre plots
	Douglas-fir		True fir		Spruce		Pine		Other		
	No.	%	No.	%	No.	%	No.	%	No.	%	
1	109	35.0	170	54.7	12	3.9	0	.0	20	6.4	311
2	37	35.9	66	64.1	0	.0	0	.0	0	.0	103
3	22	10.0	29	13.2	41	18.6	1	0.5	127	57.7	220
4	47	34.3	8	5.8	19	13.9	3	2.2	60	43.8	137
5	25	20.7	69	57.0	0	.0	27	22.3	0	.0	121
6	22	20.8	84	79.2	0	.0	0	.0	0	.0	106
7	47	74.6	13	20.6	0	.0	3	4.8	0	.0	63
8	44	13.3	259	78.5	2	.6	2	0.6	23	7.0	330
9	111	77.1	28	19.4	0	.0	5	3.5	0	.0	144
10	32	38.6	38	45.8	3	3.6	10	12.0	0	.0	83
11	41	12.7	222	69.0	58	18.0	1	0.3	0	.0	322
12	96	41.0	56	23.9	80	34.2	2	0.9	0	.0	234
13	18	20.5	58	65.9	1	1.1	0	.0	11	12.5	88
14	42	20.3	72	34.8	10	4.8	2	1.0	81	39.1	207
15	16	19.5	32	39.0	19	23.2	0	.0	15	18.3	82
16	7	2.6	188	70.7	30	11.3	0	.0	41	15.4	266
17	15	10.1	51	34.2	2	1.3	0	.0	81	54.4	149

Table 4.--Percent Douglas-fir defoliation on 1-acre blocks, Western Spruce Budworm Damage Assessment Project, Carson National Forest, New Mexico, 1978 and 1979.

Blocks	Percent defoliation [a]			
	1978 [b]		1979	
	6-class	Visual	6-class	Visual
1	47.5	40.3	88.1	94.7
2	47.0	33.7	80.2	72.6
3	64.8	50.7	86.0	89.0
4	69.1	63.4	86.9	84.6
5	65.6	54.2	93.4	93.5
6	22.0	28.8	60.2	56.1
7	54.6	35.9	89.6	89.9
8	66.5	48.9	93.1	91.4
9	11.7	6.0	29.1	5.0
10	70.2	43.4	90.6	93.0
11	60.7	51.7	95.2	94.3
12	50.7	35.3	94.7	95.0
Avg. (1-12)	52.5	41.0	82.3	79.9
13	--	--	12.7	5.0
14	--	--	9.7	5.0
15	--	--	7.5	5.0
16	--	--	1.4	5.0
Avg. (13-16)			7.8	5.0
17 [c]	--	--	0.0	0.0

a/ Each block percentage is the average defoliation of 10 single-tree samples.
b/ Blocks 13-17 were established in 1979.
c/ Uninfested check block.

Table 5.--Top-killed host trees (Douglas-fir, true firs, and spruce) 5 inches in diameter or greater on 1-acre blocks, Western Spruce Budworm Damage Assessment Project, Carson National Forest, New Mexico, 1978 and 1979 [a/].

Block	Total no. host trees	Old top-kill [b/]		1978				1979			
				Top-killed		Dead		Top-killed		Dead	
		No.	%	No.	%	No.	%	No.	%	No.	%
1	190	2	1.1	4	2.1	0	0	70	36.8	1	0.5
2	218	8	3.7	0	.0	0	0	38	17.4	0	.0
3	103	3	2.9	0	.0	0	0	13	12.6	1	1.0
4	118	0	.0	2	1.7	0	0	55	46.6	0	.0
5	29	0	.0	7	24.1	0	0	7	24.1	0	.0
6	49	0	.0	14	28.6	0	0	5	10.2	0	.0
7	216	0	.0	1	0.5	0	0	19	8.8	1	0.5
8	138	7	5.1	1	0.7	0	0	32	23.2	0	.0
9	98	1	1.0	1	1.0	0	0	0	.0	0	.0
10	106	10	9.4	2	1.9	0	0	16	15.1	0	.0
11	127	2	1.6	0	.0	0	0	57	44.9	0	.0
12	171	4	2.3	0	.0	0	0	21	12.3	0	.0
Avg. (1-12)	130.2	3.1	2.4	2.7	2.0	0	0	27.8	21.3	0.2	0.2
13	163	0	.0	--	--	--	--	0	.0	0	.0
14	141	17	12.1	--	--	--	--	0	.0	0	.0
15	177	5	2.8	--	--	--	--	0	.0	0	.0
16	320	3	0.9	--	--	--	--	0	.0	0	.0
Avg. (13-16)	200.2	6.2	3.1	--	--	--	--	0	.0	0	.0
17 [c/]	204	3	1.5	--	--	--	--	0	.0	0	.0

a/ Blocks 13-17 established in 1979.
b/ Top-kill prior to and not attributable to current budworm infestation.
c/ 17 is uninfested check block.

Table 6.--Top-kill and mortality of host trees . than 5 inches d.b.h., Western Spruce Budworm Damage Assessment Project, Carson National Forest, New Mexico, 1978 and 1979 [a/].

Block	Total no. host trees [b/]	1978				1979			
		Top-kill		Dead		Top-kill		Dead	
		No.	%	No.	%	No.	%	No.	%
1	291	0	.0	0	.0	41	14.1	4	1.4
2	103	2	2.6	0	.0	1	1.0	0	0
3	92	0	.0	0	.0	0	.0	1	1.1
4	75	0	.0	1	1.8	2	2.7	0	.0
5	94	0	.0	0	.0	1	1.1	0	.0
6	107	0	.0	1	1.2	6	5.7	0	.0
7	60	0	.0	0	.0	1	1.7	0	.0
8	306	0	.0	1	0.5	6	2.0	11	3.6
9	139	0	.0	0	.0	0	.0	1	0.7
10	73	0	.0	0	.0	2	2.7	0	.0
11	321	0	.0	0	.0	5	1.6	6	1.9
12	232	0	.0	0	.0	1	0.4	0	.0
Avg. (1-12)	157.8	0.2	0.1	0.2	0.2	5.5	3.5	1.9	1.2
13	77	--	--	--	--	1	1.3	1	1.3
14	124	--	--	--	--	2	1.6	2	1.6
15	67	--	--	--	--	0	0	0	0
16	225	--	--	--	--	4	1.8	2	0.9
Avg. 13-16)	123.2	--	--	--	--	1.8	1.4	0.4	1.0
17	68	--	--	--	--	6	8.8	0	0

a/ Blocks 1-12 established 1978; 13-17 in 1979. Top-kill and mortality present year of plot establishment will be used as baseline data and will not be attributed to budworm.
b/ Equals total number of Douglas-fir, true fir, and spruce seedlings and saplings found on nine, 1/100-acre plots per block the year of block establishment.
c/ Uninfested check plot.

Table 7.--Larval and egg mass densities, Western Spruce Budworm Damage Assessment Project, New Mexico, 1978 and 1979. a/

Block	No. larvae/ 100 buds 1979	Egg masses/m^2 of foliage b/ 1978	1979
1	36.6	41.1	25.5
2	20.3	11.1	34.0
3	26.8	17.0	39.5
4	21.7	34.9	35.1
5	29.2	25.1	32.8
6	15.9	13.1	36.6
7	29.2	27.3	47.6
8	33.2	24.2	33.0
9	7.7	3.6	21.5
10	28.9	21.5	40.2
11	28.9	15.2	67.9
12	25.9	13.6	39.6
Avg. (1-12)	25.4	20.6	37.8
13	0.8	--	25.4
14	0.2	--	16.5
15	0.3	--	.0
16	0.1	--	3.3
Avg. (13-16)	0.4	--	11.3
17 c/	0.0	--	.0

a/ Blocks 1-12 established in 1978; 13-17 in 1979.
b/ Average for 10 Douglas-fir trees per block; 2 branches per tree.
c/ Uninfested check block.